PN-AAK-768

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RENEWABLE ENERGY AND CHARCOAL PRODUCTION

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October 1978

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ACKNOWLEDGEMENT

I wish to thank Dr. Walter E. Parham and Roger D. Moeller of the Office of Science and Technology, AID, Washington, D.C., for their guidance and assistance in preparing this document. My appreciation is also extended to Messers. Joesph Wainwright, Robert Cassaguol and Yves Guery and the staff of the Department de l"Agriculture des Ressources et du Developpment Rural and USAID Mission/Port-au-Prince in Haiti for their hospitality and assistance during my consultancy in Haiti.

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PREFACE

Haiti is in a state of crisis! This has been brought about by a growing population, unemployment, malnutrition, low productivity, a severe shortage of renewable and reasonably priced alternative sources of energy and misuse of the land.

We need forests, not just for lumber and fuel. We need them because they provide oxygen and help control temperature and climate. They collect and store rainfall, provide a wildlife habitat and prevent soil erosion.

Maybe science can find a substitute for wood as lumber and fuel—but not for the rest of these services. Ironically, as forests are 'harvested' for a profit in a few pockets, lumber becomes too expensive for the average family and the cost of firewood and charcoal drain the family budget.

AID has recognized that the destruction of forests hampers economic growth in developing countries. One activity that may reduce damage to the remaining forests is "tree farming". This means planting and cultivating trees as if they were an agricultural crop. Like other crops, the trees would be systematically harvested on a sustained yield basis for fuel, fertilizer or fodder. For the past few years, American and other scientists have studied this method of growing trees and are convinced that enormous numbers of trees can be grown rapidly for soil conservation, for use as fuel and associated benefits. Tree farming, in addition to providing fuel, can offer employment to rural inhabitants and provide an energy base for rural industries.

Beneficiaries

Food, water, shelter, and warmth clearly are basic human needs, and to provide for each of these needs in Haiti requires a sustainable forest cover on certain parts of their land. How does a forest cover benefit the poor in Haiti? Rains now are stripping the country's soil at an unusually high rate. When soils disappear so does food. In the past, forest blanketed the hills, erosion from runoff was slowed, groundwater was recharged, and streams flowed year round. Dry streams and falling water levels in wells now severly affect the rural poor. Eroded silt from the treeless hills damages the breeding grounds of aquatic food resources, shrinks the water storage capacity of reservoirs, and destroys the hydroelectric potential of costly dams. As forests disappear so do the poor's building materials, and in Haiti many of the rural people already live in shelters of sticks and mud. The habitats for birds and other wildlife have diminished thus reducing the normal population of important insect predators, the result being increased crop losses from army worms and the like. Firewood and charcoal for warmth and cooking--where will they come from if the tree cover continues to be erased?

It is evident that the beneficiaries of this project will incompass not only the poor but the entire social--economic strata of Haiti.

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RENEWABLE RESOURCE SYSTEM FOR USE OF THE HAITIAN FORESTS

A WORKING PAPER

(see ANNEX 1)

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RENEWABLE ENERGY PLANTATIONS FOR CHARCOAL PRODUCTION

The Problem

Haiti is in a state of crisis! This has been brought about by a growing population, unemployment, malnutrition, low productivity, a severe shortage of renewable and reasonably priced alternative sources of energy and misuse of the land. The lack of adequate amounts of arable land and the cutting of trees as a source of fuel, firewood and charcoal, has resulted in the massive deforestation of the hills and mountainsides, causing accelerated erosion, soil depletion and severe environmental degradation. Food production per hectare in Haiti is presently one of the lowest in the world. The productivity level continues to decrease as population increases and as the physical and biological resource base deteriorates further exacerbated and accelerated by increased soil erosion and water losses directly resulting from deforestation (USAID/IAD Project Paper No. 521-T-008, 1976-79). Haiti could be considered the epitome of the theory of "circular causation:" Low nutritional intake, poor health, under-employment, low productivity, etc.

It is estimated that over 97 percent of the population of Haiti cook their food using wood or charcoal. The majority of charcoal in Haiti is consumed in Port-au-Prince. Barren, eroded hills show clearly the results of man's quest for firewood. The United Nations reported in 1976 that the charcoal industry in Haiti would only be able to satisfy

the demand fuel needs for ten years. (Reader-Roitch and Zenny, 1975). Is Haiti to become the first victim to the "Malthusian Theory?"

Consumption Estimates

The total amount of wood consumed per year has not been accurately assessed in Haiti and any figure given would be highly approximative. Lundahl (1976) projects a total wood consumption figure of about 20 million m^3/yr. Whitney(1978) estimates a consumption rate of 12 million m^3 of wood/yr, and of this amount, 10 million m^3 is used for cooking. The UN-FAO reported in 1975 that the amount of natural forest remaining is estimated equivalent to 150 million m^3 of solid wood. Wood consumption in 1974 was estimated at 4.75 million m^3/yr (solid-wood equivalent), with firewood and charcoal amounting to about 95 percent of the total (Raeder-Roitsch and Zenny, 1975). Estimates by the Ministry of Agriculture, however, show household consumption even higher at 5,056,000 m^3 solid-wood equivalent (Wainwright, 1976, as cited by Zuvekas, 1978). This figure has been questioned because the growth rate of the number of households was only half that used by Wainwright. The projected annual forest regrowth was estimated to be only 1 million m^3 (Raeder-Roitsch and Zenny, 1975). Earl (1976), however, gives a more conservative estimate of the consumption of wood for fuel as approximately 4 million m^3 in 1976, giving a *per capita* consumption of 0.87 m^3. Of this amount 436,800 m^3 was converted to charcoal yielding an estimated 54,600 mt.

Conservation Foundation (1977) estimated Haiti's population to be approximately 5 million. Thus, the present annual rate of fuel-wood/charcoal consumption would be 4.35 million m^3 using the *per capita* consumption

WOOD CONSUMPTION AND FOREST REGROWTH IN HAITI

TABLE 1 Remaining Natural Forest

Year	Wood in m^3
1975 1/	150 million m^3 (solid wood equivalent)

TABLE 2 Total Wood Consumed

Year	Wood in m^3
1953 2/	8.87 million m^3/yr
1968 2/	13.125 million m^3/yr
1974 1/	4.75 million m^3/yr
1976 3/	5 million m^3/yr (solid wood equivalent)
1977 2/	20 million m^3/yr (approx.)
1978 4/	12 million m^3/yr (approx.)

TABLE 3 Projected Annual Forest Regrowth

Year	Wood in m^3
1975 1/	1 million m^3

WOOD CONSUMPTION AND FOREST REGROWTH
IN HAITI
(continued)

TABLE 4 Consumption of Wood for Fuel

Year	Wood in m^3
1976 5/	4 million m^3

TABLE 5 Consumption of Wood for Cooking

Year	Wood in m^3
1975 1/	4.57 million m^3
1978 4/	10 million m^3

TABLE 6 Charcoal Consumption in Port-au-Prince

Year	Wood equivalent m^3 (8 m^3 wood = 1 ton charcoal)
1970 5/	0.112 million m^3
1974-75 5/	0.437 million m^3

WOOD CONSUMPTION AND FOREST REGROWTH
IN HAITI
(continued)

REFERENCES

1/ Raeder-Roitsch and Zenny, 1975

2/ Lundahl, 1976

3/ Wainwright, 1976, as cited by Zuvekas, 1976

4/ Whitney, 1978

5/ Earl, 1976

figure of 0.87 m^3. However in Earl's calculation, he mistakenly used the figure for the net loss of forest resources (3.75 million m^3) and not the figure reported for the total amount consumed, 4.75 million m^3. Regardless of which figure is correct it is relatively a moot point because a downward adjustment in demand projections only suggests a postponement of the crisis but does not eliminate it. What it does mean though is that in 1974 the forests were being cut down at 4.75 times the estimated rate of regrowth.

As many as 1 million people of Haiti's total 5 million population live in urban areas. Here it is estimated that 40% of the families use charcoal for part of their domestic fuel requirements. Approximately 30% of the total amount of charcoal produced is consumed in the Port-au-Prince area where the consumption of charcoal increased by 13,000 mt from 1970 to 1975, averaging 19%/yr (Earl, 1976). Charcoal consumption will have risen to approximately 40,000 mt in the Port-au-Prince area and 80,000 mt nationwide by 1979 if Earl's projections hold true. The charcoal consumption would be disproportionate in other areas, however, due to out-migration from outlying areas to the rapidly expanding urban population of the Port-au-Prince area.

Environment and Charcoal Production

Charcoal-making activities are often preceded by burning operations to kill the trees before they are cut down. The reason for the burning are both institutional and technical. Charcoal-makers are allowed to cut

"dead" trees to make charcoal so when the trees are killed in the process of burning, it legalizes the cutting of the tree. Haitian law forbids tree cutting without a permit. However, this statue is nearly impossible to enforce and, who can deny a Haitian fuel to cook his food nor the right to live. In addition, "dead" trees (cured wood) burn completely in the charcoalization process producing a higher quality of charcoal than that from freshly cut trees (green or uncured wood). It is also easier to harvest the trees since thorns on the trees, cacti and underbrush are burned in the process. Unfortunately, trees that are burned before felling usually do not coppice [ratoon or sprout (Earl, 1976)]. Once the trees have been cut, goats and cattle browse the coppice that have survived the burning, as well as any newly sprouted seedlings, killing them and preventing the natural process of forest regeneration. Each year as more trees are cut down, the rate of natural regeneration cannot match the rate of consumption, acellerated erosion results, environmental degradation is excerbated, wood progressively becomes scarcer, the price of fuelwood and charcoal soars and the people get progressively poorer. Estimates of the past few months suggest that the price of charcoal has increased as much as 20 percent, further evidence that wood is becoming scarce. The lack of a readily available and inexpensive substitute for charcoal and firewood, coupled with the present rate of forest destruction, points to an impending fuel crisis in Haiti.

USAID's Present Reforestation Efforts

The USAID/DARNDR Integrated Agriculture Development Project* targets for watersheds for soil conservation and "reforestation". Reforestation may be a misnomer for unless large parcels of state land are released to DARNDR, the best that can be done is to get farmers to plant a few trees. One of several watersheds in the Jean Rabel region is targeted for "tree planting" under this program. The other three targeted watersheds in the project are located in the Jacmel, Les Cayes and Thomazeau regions. Road construction is also part of the project, however, when roads are built to "service" rural areas they sometimes serve as vehicles to accelerate deforestation and environmental degradation. Persons who deal in wood and charcoal are provided access to areas that were previously inaccessible.

Each week an estimated 12,000 sacks of charcoal leave the Jean Rabel region for the Port-au-Prince area. A sack of charcoal weighs 30 kg (30 kg x 12,000 sacks = 360,000 kg or 360 mt). To produce one metric ton of charcoal requires abc.t 8 m^3 of wood (8 m^3 x 360 mt = 2,880 m^3 (Earl, 1976)). The deforestation of the Jean Rabel region is proceeding at a rate of 288 ha/week or 14,024 ha/yr, based on Earl's estimated growth rate of 10 m^3 wood/ha/yr. Earl calculates that approximately 1 million ha/yr of the total forest cut naturally regenerates.

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* USAID/DARNDR - United States Agency for International Development in cooperation with the Department de l'Agriculture des Ressources et du Developpement Rural. The Acronym for the Integrated Agriculture Development Project, in English, is IAD Project and in French, PDAI.

The deforestation rate of Jean Rabel region nevertheless is proceeding at a rapid pace of 10,581 ha/yr. USAID/DARNDR has yet to estimate the size of the Jean Rabel watershed but it probably does not exceed 10,000 ha. Under ideal conditions, less than 20 percent of this amount could be "reforested" -- planted to trees during the five year life of the project. While 2,000 ha of trees are being planted through the USAID/DARNDR IAD Project, charcoal producers will be busily cutting down some 53,000 hectares of trees. The rate of deforestation will exceed reforestation by a factor of 25. "Frightening?"

The Haitian peasant must cut trees to clear his land for cultivation and for fuel-wood. To change the agricultural practices of some 3.85 million peasants would be a monumental task and would require an educational process that would span generations. New improved agricultural systems and practices like crop rotation, contouring, seed and crop selection, and agro-forestation, need to be devised and introduced. The establishment of renewable energy plantations is one such cropping system. Unfortunately, it is not possible to establish the value of ecological and social gains in a financial analysis of such changes.

Alternative Sources of Energy in Haiti *

Possible fuel substitutes for charcoal and firewood are:

(1) Petroleum Products -- Haiti is now totally dependent on imports for obtaining petroleum products. Lundahl (1976) states that "petroleum

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* A useful survey of technologies appropriate to the rural sector is contained in National Academy of Sciences, Energy for Rural Development, NAS, Washington, D. C. 1976

reserves no doubt exist in Haiti but their extent is not known". Woodring, Brown and Burbank (in 1974) conducted surveys showing that favorable geological conditions exist that indicate the possible presence of oil deposits in Haiti. The Atlantic Refining Co. (between 1944 & 1947) undertook a series of test drillings that confirmed these geological results, while a series of drillings in the Ile de la Gonave in the mid-fifties (by John Mecom, Commonwealth Oil Co.) were less successful. Additional exploration was said to have taken place in 1977 but the results are unknown. Oil has been found in the Azua region of the Dominican Republic in a geological setting similar to that of the Haitian Plateau Central (Lundhal, 1976). Regardless of whether or not petroleum deposits exist in Haiti, oil would not be marketed nor have any impact as a fuel resource for the foreseeable future.

(2) Coal -- Haiti lacks coal deposits having high carbon content, but seems to possess the most extensive lignite deposits of the West Indies. The fuel value of the lignite, however, is comparatively low and its high ash content reduces its fuel value (Lundhal, 1976). But, it is possible that these deposits could be economically exploited by the conversion of this lignite, through the process of coal gasification,* into a more useable form of energy.

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* Gasification: Wood or coal can be used as a raw material for the production of producer gas (carbon monoxide) and water gas (carbon monoxide and hydrogen). The most efficient use of producer gas is in boilers, since heat generated by the exothermic process is captured. In 1969, wood-fueled producer gas plants were operating in several LDCs, Kenya, Sri Lanka, India, and West Africa). Water gas can either be burned or used for the synthesis of methanol (Palmedo, et al, 1978).

(3) Bilogical Waste — Methane gas can be developed from food and agricultural wastes and sewage slime. Systematic cooperation of large numbers of Haitians would be required for collecting adequate amo nts of organic matter to support significantly large methane production. Sewage collection, at the present time, seems to be the greatest obstacle to such a scheme. However, it has been reported that the Inter-American Bank is exploring this potential.

(4) Hydroelectric — Haiti is estimated to have the potential for producing 148,685 KW of hydroelectric power (Lundhal, 1976). Extreme denudation of watersheds and accelerated rates of erosion resulting in heavy siltation, however, inhibits development of this energy source. For example, the efficiency of the Artibonite Valley dam has been reduced by 40 to 60% in 20 yrs. (Conservation Foundation Letter, Nov. 1977; and Zuvekas, 1978). Thus, it is evident that the hydroelectric potential of Haiti cannot be exploited economically without massive reforestation and soil conservation efforts to reduce siltation.

(5) Geothermal -- Geothermal potential exists in Haiti in such a. as as the "Chaud Sourdre". However, exploitation of these energy sources is difficult and time consuming. Therefore, it would offer little relief to the energy needs of Haiti in the foreseeable future.

(6) Wind Energy -- Haiti lies in the belt of the northeast trade winds, with prevailing winds from the northeast or east. Therefore, wind might serve as an energy substitute for wood and charcoal (Lundahl, 1976). Wind energy generated in rural areas, however, would do little to reduce the rate of deforestation because the majority of charcoal consumed in Haiti is in the Port-au-Prince area. The wind energy potential here is limited. The large scale utilization of wind energy for the foreseeable future in Haiti does not seem a viable option.

(7) Nuclear Energy — The probability of nuclear energy becoming a solution to Haiti's energy crisis in the foreseeable future is highly doubtful.

(8) Solar Energy -- The high cost and present level of technology makes the utilization of solar energy economically unfeasible for the Haitian peasant. The widespread use of solar energy would require massive informal educational programs in rural Haiti. For the Haitian peasant to use solar energy to cook his food would require a major change in his eating habits, a difficult task to achieve in any society. The use of solar energy in major population centers, however, for heating water in hotels, hospitals, etc., is economically feasible.

(9) Renewable Dendro-energy Plantations — Today, the case for sustained yield forest management for energy production is particularly strong, given the high cost to the rural poor of alternative forms of energy for fuel (electricity, kerosene, solar power). In Haiti, however, the Government would need to take an active role in such a program in order that sufficient land be made available for establishing and systematically exploiting

renewable energy plantations. Further, they would need to offer incentives to create a favorable climate for investment by the private sector. Money would have to be made available by international lending institutions through capital investment soft loans to ease the economic burden on the private sector until plantations were established and producing wood.

Economically it is feasible to produce charcoal and firewood by raising fast-growing trees such as Leucaena leucocephala in renewable energy plantations. Renewable energy plantations are already in existence in Brazil, in which a fast growing variety of Eucalyptus is being propagated, and in the Philippines, where Leucaena is being grown for conversion into charcoal.

A Suggested Strategy

Immediate Actions to be Contemplated by the GOH and USAID

The extreme environmental degradation, exacerbated by the present inefficient system of charcoal production, and the impending energy crisis in Haiti, give credence for the justification of the following recommendations:

1. Removal of the tariff imposed on kerosene — The use of kerosene as a supplement for charcoal in the Port-au-Prince is a possibility. An inexpensive kerosene stove has been developed and manufactured in "Dutch Curacao" (Dutch Indies) costing $0.40/unit (also see Moore as cited by Lundahl, 1976). The tariff imposed on kerosene by the Haitian Government would have to be removed if such stoves were to be of economic value.

2. Subsidization of the cost of kerosene — The U.S. Government should consider subsidizing the cost of kerosene in Haiti as a temporary stop-gap measure to deter further deforestation and the likelihood of an ecological disaster.

3. A celing price for charcoal —That the GOH intervene to set a celing price for charcoal which could be adjusted in accordance to the inflationary trend. A large portion of the family budget of the urban poor of Haiti is spent to purchase charcoal for cooking food. The price of charcoal is disproportionately increasing in comparison to family incomes. The retail price of charcoal has increased by 20% according to recent reports, thus, the already desperately poor urban dwellers are fast becoming poorer. Haitians earned a per capita real income of $134 (U.S.) in 1976, about the lowest in the Americas. The figure for GNP is not much use in comparative analysis since Haiti's poor people are much poorer than the per capita figures indicate bacause of the wide disparity between the earnings of the poorest and the richest sections of the economy.

4. Licensing of all wholesale and retail charcoal dealers—That the GOH intervene to license all wholesale and retail charcoal sellers. The marketing of charcoal products will be done through the traditional small-scale marketing system. Only those wholesalers and retailers who are licensed will be permitted to engage in the marketing of charcoal. Fees collected will go to DARNDR and be used for the purposes of reforestation, the establishment and maintenance of parks and wildlife preserves, and the management of forest lands.

5. Regulation of the interdistrict (interstate) transport of charcoal — That the GOH will intervene to regulate the interdistric (interstate) transport of charcoal.

6. Exploitation of the lignite deposits — That USAID finance a study on the feasibility of the exploitation of the lignite deposits in Haiti and

the conversion of this lignite, through the process of coal gasification, into a more useable form of energy. Haiti has the most extensive lignite deposits found in the West Indies (Lundahl, 1976). Eventhough these deposits do not have a high calorific content, approximately 2.5 kcal/g at Camp Perrin and 4.3 kcal/g at Maissade (charcoal is 7.1 kcal/g), it should be possible to convert the lignite to gas (Earl, 1976). The EXON Corporation is one of several corporations who have done extensive research in the science of coal gasification. The U.S. Government should explore the possibility of financing exploitation of these deposits as an alternative source of energy to supplement the needs of Haiti if this study shows a positive potential.

7. Establishment of renewable dendro-energy plantations — It is proposed that renewable dendro-energy plantations be established through the creation of a corporation possessing a "public utility franchise" from the Haitian Government. This would put into a single organization a system for doing; create a center of cognizance; build an organization with the capabilities of accepting technology and know-how and decentralizing; and bring internal and external resources to bear on a specific problem all in a manner that within time will be self-sustaining. Leucaena leucocephala would be the tree species used, characterizing the initial establishment and operations phase.

Renewable Energy that is a Reality

Denis Hayes of the World Watch Institute (1976) stated that "Two years ago the world appeared to have three energy alternatives on which to build a substainable post-petroleum world: coal, nuclear power, and solar energy. Today we have one clear-cut option: the sun."

The late English economist E. F. Schumacher in his epic book, Small is Beautiful, summed mankind's problems today as:

> "Since fossil fuels, the mainstay of the modern system, have ceased to be cheap and may soon cease to be plentiful, many people are becoming interested in solar energy. They are looking for all sorts of man-made contrivances to collect solar energy. I am not sure that they always appreciate the fact that a most marvelous, three dimensional, incredibly efficient contrivance already exists, more wonderful than anything man can make -- the TREE."

Charcoal Production in Haiti

High unemployment in rural areas results in the cost of labor being very low. Charcoal-makers in 1976 received much less than the official minimum wage rate of $1.30/day, and when fully employed in making charcoal produce approximately 60 kg/day earning $0.60 (@ $0.30/30 kg sack). Woodcutters can cut approximately 2 m^3 of stacked wood/day, earning approximately $0.40/day (@ $0.20/$m^3$). Approximately 4,370 persons are employed full time in the production of charcoal with an aggregate earning of $540,000 (U.S.)/yr , an average of $124 per capita (Earl, 1976). By using Earl's 1973 annual consumption estimates of 3.75 m^3 of firewood/charcoal and his conversion rate of 8 m^3= 1 ton, we obtain an equivalent of 0.46 millions tons of charcoal/wood consumed. Converting this to 30 kg/sack at a price of $3.00/ sack, we see that Haiti's charcoal/wood industry has a value of approximately $45 million per year, with a per capita expenditure of $10.00/yr.

The price of charcoal in Port-au-Prince is $3.00 a sack ($0.10/kg). The price is reported to increase by 20% or $3.60/sack when sold piecemeal. A sack of charcoal weighs approximately 30 kg, and the peasant who produces the charcoal receives approximately $0.60/sack. Transportation costs are reported

to be as high as $0.75/sack when transported by truck for long distances.* Thus, the middleman makes the lion's share of the profit in the charcoal industry.

Haitian peasants produce charcoal, using the traditional earth kiln (pit kiln) technique. Seventy-five percent of original energy potential of wood is lost in the process of charcoal-making but charcoal itself has a much higher energy content and gives smokeless heat, thereby making it more suitable for indoor cooking (Vietmeyer, et al, 1977). The U.S. Department of Forest Service, however, gives the energy conversion rate for light hardwoods to charcoal (dry weight) as 30.0 percent (USDA, 1962). Whitney (1973) reports that 5 m^3 of wood are required to make one m^3 of charcoal accounting for a conversion rate of 20%. The OAS estimates a production yield of 7.3 m^3 of wood/ha/yr (Doc. PEPA/Haiti 78/008, cloture), while Earl (1976) projects a yield of 10 m^3 of wood/ha/yr.

Earl (1976) calculated that, if a fuel plantation were established and maintained, the production cost for wood would be $5.83/$m^3$. However, I find that in his calculations his establishment costs were included as a yearly expense for each of the eight years. This cost factor should only be repeated if the entire plantation is cut each year and the particular species of tree planted does not coppice (ratoon). Moreover, Earl's planting costs seem extremely high.

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* These figures were obtained in interviews with individuals in Jean Rabel but have yet to be verified. Transportation costs of $0.40/bag might be a more reasonable figure. Often times the trucker and the retailer are one and the same. In the following suggested project strategy this cost would be greatly reduced by locating the "Renewable Energy Plantations" nearer the Port-au-Prince area and by the utilization of the "sugar cane train" rail line that is already in operation.

The Organization of American States (OAS), through DARNDR, at present proposes to finance the establishment of a 5,600 ha charcoal production plantation over an 8 year period of time in Jean Rabel (Appendix A) with a proposed cost of $2,856,104.00 (U.S.). Return on the project is expected to be 4,260,087 sacks (30 kg ea.) of charcoal or $6,340,956 worth of product over a 16 year period with an estimated return of 7.0% per year on their investment. The OAS projected annual wood yield is only 7.3 m^3 of wood/ha/yr. If, however, we use Brewbaker's (1975) yearly yield figures for Leucaena of up to 100 m^3 of wood/ha and the projected cost/benifit analysis of the OAS project, we find that Leucaena would give a significantly increased return on the investment

Although the OAS proposal sounds appealing, its practicality is limited. The two major limitations to the proposal are evident. OAS has chosen the town of Jean Rabel as the proposed site. Jean Rabel is quite far from Port-au-Prince, the main market for the charcoal. Furthermore, the Jean Rabel area is densely populated and all of its arable land is cultivated. The majority of the Haitian peasants are marginal farmers but here little marginal land is available. Marginal farmers cannot afford to gamble and take risks for fear of failure. To fail may mean disaster for the farmer and his family. It is unlikely that few, if any, farmers will risk tieing up their farm land with trees for a period of 16 years and risk starvation in the meantime. Even DARNDR, who is charged with the responsibility of carrying out the program, will tell you that "land in Jean Rabel is not available and cannot be obtained for the production of charcoal." Secondly, it is a government/business program. Governments the world over have a poor track record for running businesses. For success, the production of charcoal in

Haiti must be a business that is profit oriented. To quote the late Senator Hubert H. Humphrey (November 16, 1977), "There is little reason to hope that a purely public effort in the transfer of renewable energy technologies would be successful. The success of that program could only be measured by the follow-up activities of private entrepreneurs seeking to expand their markets and consequently the use of renewable energy technologies in developing countries." Therefore, the establishment of energy plantations must be left up to the private sector.

Fast Growing Tree Species

It is proposed that Leucaena leucocephala should be the tree used characterizing the initial establishment and operations phase of "renewable dendro-energy plantations" in Haiti. The prolific nature of Leucaena, the ease of its establishment and management, its ability to regenerate after cutting (coppice), its adaptability, its tolerence to highly alkaline soils (which is the composition of the soils of Haiti), its rapid growth rate and its quality of producing high yields, gives credence to the justification of its use. Comparitive plantings have proved its value as a fast--growing--high yielding wood for use in "renewable dendro-energy plantations" in Haiti. In these plantings Leucaena, compared to two other fast growing--high yielding tree species, Eucalyptus and Casuarina, proved to be superior in its adaptability and rate of growth. However, simultaneous plantings of other tree species will be evaluated as to their biological suitability, economic value and export potential. This diversification would help offset any unknown biological problems that might arise from a monoculture.

A common varie of Leucaena has been recorded in the Philippines as yielding 88 m^3/ha in one year and 120 m^3 in 2 years (Renge & Curran, 1976; and Vietmeyer, et al., 1977). The new "Giant" varieties of Leucaena are estimated to yield as much as 100% more than the common varieties. If Leucaena species were to be grown in Haiti, a scientific approach to reforestation would have to be carried out to include the inoculation of the

seed with a high yielding strain of rhizobium, the addition of adequate levels of appropriate fertilizers, varietal selection aimed at maximizing the rate of growth and density/BTU value, and seed selection from preferred parental stock selected according to size and specific gravity to give optimum and even growth.

Plantation establishment would not be a reoccuring cost if Leucaena were the tree species selected due to the tree's ability to coppice. This would reduce the production costs to $\$3.03/m^3$ of wood produced compared to Earls' projected costs of $\$5.83/m^3$ since replanting can be avoided. The ease of establishing Leucaena by dibbling* (Benge, 1977, appendix B) could reduce costs further to approximately $\$1.21/m^3$ of wood, thus reducing the production costs by more than 79%.

Brewbaker (1975) conservatively estimates that Leucaena will yield 100 m^3 of wood/ha/yr or ten-times the per hectare yield estimated by Earl (1976). The per ha establishment and maintenance costs would remain constant despite the yield, however, a per ha yield increase would reduce overall production costs/sack of charcoal due to the volume processed. It would also increase labor requirements creating more employment.

Wood for charcoal is at present obtained virtually free, as a royalty of \$0.05(U.S.).sack amounts to lnly $\$0.20.m^3$ (Earl, 1976). As wood grows

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* Dibbling is a simple method of direct seeding whereby a pointed stick is used to punch a hole in the ground into which seed is placed and covered with dirt by a sweep of the foot. A modified hand corn planter can replace the dibble and greatly increase the sowing rate (see Appendix B).

scarcer, it is likely that the charcoal producers will continually pay higher prices for wood. Leucaena, therefore, seems very competitive.

Carriedo, K8, K28, K67 and K72, varieties of Leucaena, are recommended for planting. Seed tree plantations are needed to be established to insure a constant supply of high-quality certified seed. Seed will be selected from the most desirable "mother trees" possessing the qualities of: optimum height, straightness, rapidity of growth, density, etc. Seeds for planting should be graded as to size (large) and specific gravity (heavy). All succeeding generations of seeds F_1, F_2, etc. should be selected by the same process. All plantings should be done scientifically, to include inoculation with the proper strains of rhizobium,* fertilizers, etc. Experimentation should be conducted to determine which varieties of Leucaena are best suited for propogation by determining maximum growth rate, best charcoaling properties, highest BTU values, climatic and topographical suitability, etc. Varieties for propogation will be selected accordingly.

A 3,200 hectare plantation of Leucaena, managed on a sustained yield basis, would be needed to grow enough wood to satisfy the projected charcoal consumption for Port-au-Prince for 1979 if Brewbaker's estimate and Earl's projections

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* Commercial quantities of inoculum may be obtained from: J. Burton, Nitratin Corp., 3101 West Tuster Ave., Milwaukee, Wisconsin 53209.

Renewable Energy Plantations

It is proposed:

1. That a study be conducted by Stanford University and the Natural Energy Institute of Hawaii on the feasibility and economics of the establishment of renewable energy plantations, the present rate of production and consumption of charcoal, identification and land tenure status of the charcoal producers and persons who cut and haul wood for charcoal production, and the economics of charcoal production in Haiti. Stanford University and the Natural Energy Institute of Hawaii* has probably conducted more research in this field than any other universities or groups. They have published a book on the economic feasibility of renewable energy production (wood) in the U.S. (Reynolds, et. al., 1973).

2. That a review of the present laws and statutes be conducted concerning the leasing of state land. In addition, a study should be conducted of the records of Bureau of Contributions to determine under what contractual conditions are state lands presently leased, to whom they are leased and that these be identified as to location and size.** The initial phase of this study should focus on state lands from Port-au-Prince North along Route 101 to Gonaives, inland from Route 101 to Thomazeau and up to 500 m above sea level.

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* This study was conducted for and in the Cooperation with the National Energy Institute of Hawaii at the University of Hawaii, Honolulu, by Professor Channing Robertson, Department of Chemical Engineering at Stanford University and Dr. Donald Grace, University of Hawaii Center for Energy Research and Dean John Shupe, National Energy Institute of Hawaii at the University of Hawaii.

**It is recommended that a person from the U.S. Department of Interior be be brought in to conduct these studies (PASA Contract).

3. That a land use map be made of both state and private lands in the aforementioned areas and in the same sequence.

4. That a review be conducted of present laws and statutes concerning reforestation, and specifically those which deal with the mandatory reforestation of state land by the lessors of that land.

5. That the U.S. Government intervene on the ambassadorial level with the GOH to encourage release of all state land for management to the Departement de l'Agriculture des Ressources Naturelles et du Developpement Rural. Phase One of this release should concentrate on those lands mentioned above (no. 2).

6. That once these state lands are under the management of DARNDR, all lessors of state land will be informed that if said land is not properly managed and is not being productively used,* the lessors will have the choice of either reforestating the land or their lease will be invalidated.

7. That state land along route 101 from Port-au-Prince to Gonaives be set aside by DARNDR for the establishment of "Renewable Energy Plantations."

8. That the GOH grant a "Public Utility Franchise" to include the power to exercise the "right of eminent domain" to a segment of the private sector (specified below in No.11) in order that a renewable wood-fuel/forest potential can be re-established, developed and exploited to reverse the present trend of acute and accellerated environmental degradation.

9. That the U.S. Government provide capital development soft loans, through local lending institutions, to private U.S. companies for the development of "Renewable Energy Plantations."

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* A clear definition of this term will be made by DARNDR.

10. That the U.S. Government provide incentives such as tax breaks, etc., to these U.S. private companies for the purpose of encouraging them to participate in reforestation of Haiti through the establishment of Renewable Energy Plantations.

11. That a corporation be formed, which I will term FORTEC (Forest Technology Corporation), and registered with the Haitian Government.

a. A charter will be drawn up on this corporation specifying its purpose, objectives, etc. FORTEC will have a board of directors and be able to sell shares of stock in the corporation. The primary objective of FORTEC would be to create a technology source to re-establish, develop and exploit a wood-fuel/forest potential in Haiti.

b. These above mentioned objectives will be achieved by FORTEC carrying out the following activities:

(1) Research and Development
(2) Reforestation
(3) Forest Management
(4) Wood Production
(5) Wood Conversion

Discussion of the above points is given below.

Research and Development — The research and development component of FORTEC would encompass the following:

(1) It is suggested that research and development of wood-fuel/forest type activities be conducted under contract financed by direct (US) AID funding.

(2) FORTEC would coordinate its research and development activities with DARNDR and share the results of these activities with them.

(3) A rhizobium production facility will be established in the Soils Department of the Faculty of Agriculture and Veterinary Medicine. This facility would not only produce

the strain needed by Leucaena to maximize yields, but additional strains needed to increase yields of beans and other legumes. It is suggested that this be done under separate project funding.*

(4) That FORTEC will research and develop the process and technique of pelletizing (with rhizobium and fertilizer) and the aerial seeding of Leucaena in cooperation with DARNDR (see attached paper, "Dibble", Appendix B).

(5) That technical and monetary assistance be offered simultaneously to other areas of Haiti for the purpose of reforestation for the production of renewable energy. These energy plantations will be incorporated into FORTEC; that technical and monetary assistance will be given to any small farmer for the purpose of reforesting his land for the production of charcoal on a sustained yield basis. This charcoal will be marketed through FORTEC. No small-scale producer will be able to market any more than the projected yield of lands that he owns, leases or rents. This is designed to reduce the poaching of trees from government land. Initial funding may be by a grant combined with a loan.

(6) Research on Leucanca and other tree species will be conducted as outlined in the previous section, "Fast Growing Tree Species".

(7) That FORTEC will cooperate with USAID/DARNDR to research and develop more "appropriate technology" to increase the efficiency of the charcoal stoves used in Haiti. Japan, Taiwan, Philippines and Guatemala are among some countries that have developed relatively more effecient stoves which are simple to construct from clay (see appendix C). The production of these stoves would not only save energy but create a cottage industry as well.

(8) That FORTEC will research and develop improved methods of charcoal production and the utilization, through pyrolisis, of the by-products produced in the process of charcoalization. FORTEC will initially employ labor intensive methods in the production of charcoal such as the present day "earth (pit) kiln" method. This method of production,

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* The development of a rhizobium production facility could be done either through a U.S. university, such as the University of Hawaii NIFTAL Project, Maui Agriculture Research Center. P.O. Box 187, Kula, Maui, Hawaii 96790, or a private firm, such as J. Burton, Nitratin Corp., 3101 West Tuster Ave., Milwaukee, Wisconsin 53209

however, may be phased out as the enterprise grows, and other methods of charcoal production prove to be more economical. FORTEC would then absorb the charcoal producers into more productive labor if new methods of production are adopted. Because approximately 75% of the energy of wood is lost in the charcoaling process, new improved methods of charcoal production will be developed which will utilize this lost energy. One such method is the 4 stage forced-air-draft charcoal production unit (currently in use in the Philippines). Hot air, recombustible gases and tars are by-products that are generally wasted in the charcoaling process. The hot air and recombustible gas, through pyrolitic conversion (see Appendix D), can be utilized for the generation of electricity to power such industries as lumber mills, etc. The electricity generated could be used in the workers housing areas or channeled into the main power grid of Port-au-Prince. One use of the tar would be as a wood preservative.

Wood Production — As FORTEC begins to fulfill the needs of the charcoal market, diversification will take place to include the following:

(1) The planting, production and marketing of wood on a sustained yield basis to be used in the handicraft industry, for construction purposes, and for the manufacture of hardboard (masonite), particle board, cardboard, pulp, etc. Emphasis will be placed on the reforestation of the Artibonite Dam watershed as well as other potential hydroelectric sites, watersheds for irrigation systems and other critical erosion areas that are economically important as part of the expanded wood-energy and wood industry schemes.

(2) Appropriate feasibility studies will be made in relation to market potential of these products as well as an appropriate technology devised to develop this industry.*

(3) The aforementioned diversification will be achieved by exploiting the development potential of the small entity and the entrepreneur through the issuance of franchise licenses at a fee of 1% of the gross. A total specification package would be furnished and compliance to standards set by FORTEC in cooperation with DARNDR.

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* U.S. Forest Products Laboratory (USDA), Madison, Wisconsin, has done extensive research in this area.

(4) The same strategy will be used in the development of a diversified wood resource base as was used in the development of the "Renewable Energy Plantations", to include the utilization and exploitation of state lands.

(5) A technology package will be furnished to these "private growers" by the research and development section of FORTEC.

c. FORTEC's charter would stipulate that the company would operate on a profit-sharing basis with the employees. The profit sharing will be in the form of health benifits including family planning, education, housing, and a 30 year retirement insurance plan. Upon retirement from the company, the employee would own his/her house which could be passed on to his/her siblings but could not be sold. Further, upon retirement FORTEC would cede an amount of land (suggested 10 ha) to the employee on a "performance bond lease", stipulating that 1/4 of it could be farmed while the other 3/4 would have to be kept in trees. The land would be farmed on a 3 year rotational basis, the farmer moving to another 1/4 of his land every 3 years. The abandoned land would be replanted to trees (tree fallow). The farmer could not sell this land but it can be passed on to siblings. FORTEC in cooperation with DARNDR/USAID would assist in developing agro-forestation systems (trees intercropped with annual crops) as outlined in the attached paper "Hillside Agricultural Management Systems" (Appendix E).

d. <u>That FORTEC will offer employment to those persons engaged in the production of charcoal (identified in no. 1) with preferential treatment consideration being given to landless persons</u>. Any plan to change the future energy supplies for Haiti must take into account the large number of people who depend entirely upon the charcoal industry for survival.

e. That FORTEC offer employment, in lieu of displacement, to those squatting on government land in the areas targeted for incorporation into the proposed "renewable energy plantations".

f. That the wages of FORTEC's employees be negotiated at no less than the government wage level. This, as well as the proposed Agro-forestation scheme planned for the employees, mentioned in no. b above, will act as an incentive to draw present <u>quasi</u>-illegal charcoal producers into FORTEC.

12. That non-Haitian external companies should own no more than 49% of the stock in FORTEC and Haitians should own no less than 51%. The implementing firms should maintain the majority voting stock until all loans have been repaid.

13. That the Haitian Government lease state land to FORTEC at a rate not to exceed 6 to 9% of a pre-negotiated value of the land. This rent would revert to DARNDR to be used for reforestation activities.

14. That FORTEC be allowed to re-invest 50% of the imposed-corporate income taxes into reforestation as an investment incentive.* This reforestation would be in addition to the normal planned expansion plan of FORTEC.

15. That the Haitian Government offer to other businesses and private individuals the opportunity to re-invest 50% of imposed taxes into reforestation as an investment incentive.*

16. That the GOH intervene with private land owners who possess unimproved lands within the aforementioned targeted area. These land owners would be required to improve their land holdings by a system of Agro-forestation that is approved by DARNDR. As an alternative, the land owners would be offered the following options:

a. The opportunity to become investor/share/stock holders in FORTEC by leasing land to the company. The land owners would be given a predetermined number of shares based on the assessed value of their land. FORTEC would incorporate their land into the "renewable energy plantation".

b. The owner could seperately farm/manage his land in a "mini-energy plantation".

c. FORTEC could plant and manage their land on a contract basis. Technical assistance, extension services, harvesting and processing could be provided by FORTEC.

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* The Brazilian Government has carried out a very successful program in "investment incentives for reforestation" in lieu of taxes.

Conclusion

In conclusion, the aforementioned approach to the establishment of "Renewable Energy Plantations" for the production of charcoal in Haiti is feasible. The success or failure of such a strategy is limited only by the sincerity, innovativeness and flexibility of the U.S. Government and the GOH and their determination to do something positive toward off the impending energy crisis and the total environmental degradation of Haiti. Not only would such a program offer a source of renewable energy, create employment, introduce new farming systems, improve the living standards of the people, create cottage industries, improve the environment, water resources and the soil conditions of Haiti, but will reduce expenditures wasted on infrastructure destroyed or damaged by floods. Unfortunately, it is not possible to establish the value of the ecological and social gains in terms of a financial analysis, but in Haiti they would be high.

The best example that can be used to emphasize the need for reforestation is a quote from T. Dale and V.G. Carter's (1955) book Topsoil and Civilization:

> "Man, whether civilized or savage, is a child of nature--he is not the master of nature. He must conform his dominance over his environment. When he tries to circumvent the laws of nature, he usually destroys the natural environment that sustains him. And when his environment deteriorates rapidly, his civilization declines. How did civilized man despoil this favorable environment? He did it mainly by depleting or or destroying the natural resources. He cut down or burned most of the usable timber from forested hillsides and valleys. He overgrazed and denuded the grasslands that fed his

> livestock. He killed most of the wildlife and much of the fish and other water life. He permitted erosion to rob his farm land of its productive topsoil. He allowed eroded soil to clog the streams and fill his reservoirs, irrigation canals, and harbors with silt. In many cases, he used and wasted most of the easily mined metals or other needed minerals. Then his civilization declined amidst the despoilation of his own creation or he moved to new land. There have been from ten to thirty different civilizations that have followed this road to ruin."

Is this to be the fate of Haiti?

Perhaps we may learn from Lewis Carrol who wrote in his classic Through the Looking Glass (Alice in Wonderland):

"Cheshire-Puss," she began, rather timidly, ".... would you tell me please, which way I ought to go from here?"

"That depends a good deal on where you want to get to," said the Cat.

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Agency for International
Development
October, 1978

FILE

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FILE

ANNEX 1

RENEWABLE RESOURCE SYSTEM FOR USE OF THE HAITIAN FORESTS

DRAFT

A WORKING PAPER

Problem

Haiti is rapidly being deforested through the removal of trees to produce charcoal. Deforestation is having a profound negative impact on agricultural and hydroelectric power production due to soil erosion and reservoir silting. About 97 percent of home energy use in Haiti is based on fuel derived from wood. The need to reforest the denuded areas while increasing the supply of locally produced charcoal is urgent. A system that includes elements of reforestation, charcoal production and distribution, and technology upgrading and adaptation is required to fill the need.

Discussion

Numerous papers have been written, speeches delivered and predictions made concerning the consequences of deforestation in Haiti. The present question, simply put, is how can the present system that results in a net loss of forest, be altered to result in a net gain in forest while increasing the supply of charcoal. A secondary question concerns the method of directing or biasing the altered system to provide additional benefits and products.

The acceptance of certain premises and assumptions is

needed in order to provide direction and definition to possible system designs. It is apparent that the system will include both the government and private sectors. Efficient production and product distribution entities are more prevalent in the private sector so it will be assumed that the private sector will encompass this part of the altered system. Regulatory, police, and sovereign functions can be handled best by public-sector entities. This premise should be accepted. The successful implantation of a workable altered system will be difficult but it can be eased by making maximum use of the existing system and relationships. New relationships should not be imposed if those existing will suffice.

The present system is a four-element system consisting of the Haitian Government, charcoal producers, distributors, and consumers. The charcoal producers cut the wood, produce the charcoal and sell to the distributors. The Haitian Government is a passive element that nominally owns much of the wood but does not effectively control its use.

Proposal

It is proposed that a five-element system be created, as follows:

Element 1 - The Haitian Government

Element 2 - The Forest Technology Corporation (FORTEC)

Element 3 - Wood converters (charcoal producers

Element 4 - The distributors

Element 5 - The customers/consumers.

Only element 2, the Forest Technology Corp., would be new. Elements 4 and 5 would initially be the same people performing the same functions in the same way. Element 3 would tend also to be the same people performing the same function, but in a somewhat different way. Element 2 would be a new entity performing some new and some current functions using some new and some of the same people. Element 1, the Haitian Government, would perform mainly new functions.

FORTEC's functions and relationships to the other elements would be crucial to the proposed altered system's viability. At present, the Corporation is envisaged as a single entity covering all of Haiti, but the possibility of more than one such organization being established should not be foreclosed.

The objectives of the Forest Technology Corp. would be to ensure the efficient and beneficial use of wood from the forests of Haiti; to ensure the continuing and expanding supply of wood from the forests; to assist in the control of erosion and silting through reforestation efforts; to explore and implement, through the private sector, all uses of wood that would contribute to the economic development of the rural and urban poor of Haiti.

FORTEC would operate in the private sector as a corporation with a franchised utility-type monopoly in certain

functions granted by the Haitian Government. FORTEC would have a functional monopoly for wood production, forest management and reforestation. It would not have a monopoly in research and development or wood conversion. In fact, FORTEC's activities in the conversion function would be limited in order to prevent extension of its monopoly position on a de facto basis.

FORTEC would carry on research and development activities in all operational areas, concentrating initially on reforestation and charcoal conversion. FORTEC would place emphasis on establishing the capability of acquiring and disseminating technology and know-how locally and internationally. It would also be responsible for reforestation and forest management. Some of the techniques and technology useful in carrying out this responsibility would come from other developing countries and developed countries. Much of the know-how is in the public domain and requires only the development of the institutional and technical capability to absorb and use it in Haiti. Although a variety of trees may be used, heavy dependence on the leucaena species would characterize initial operations.

Wood production would be a monopoly function of FORTEC, but the arrangements may vary for filling this responsibility. FORTEC may produce the wood, may contract for its production, or may tie in production and conversion. FORTEC would, however, maintain control over the production methods

and rates.

In the area of wood conversion, FORTEC would limit its operation to a small market share. It would, for example, maintain operational charcoal production facilities and would franchise/license other conversion operations in the private sector. This franchise/license relationship is a key relationship and deserves more detailed discussion.

The critical requirement of the system being constructed is its ability to charge its beneficiaries with the cost of renewing and maintaining the system's natural and technological resources. The beneficiaries can be identified, and include the users and producers of charcoal, the users and producers of hydroelectric power, the agricultural community, and, in the larger sense, the whole of Haiti. In the case of the users and producers of charcoal, the franchise/license relationship to FORTEC is the key method of cost recovery. The costs would be recovered in three ways. Some of the costs of R & D would be recovered by minimal technical assistance charges to the charcoal producers. The costs of reforestation, management, and wood production would be recovered through a license fee on charcoal production and a charge for wood used. The bias in the franchise/license terms should be favorable to the smaller producer, and sufficiently flexible to include individuals who only produce charcoal and those who produce the wood and convert it to charcoal.

The distribution method would not be changed in the

near term. However, this element of the present system appears to be somewhat inefficient and tied closely to the cultural and social structure. A mid-term objective would be to improve efficiency without disturbing the important cultural and social relationships. The relationship between the distribution and charcoal-production elements would not be changed significantly.

The franchised utility-type relationship between the Haitian Government and FORTEC would be an arm's-length relationship that would grant to FORTEC the use of public lands that are currently useful for wood production and those lands useful for reforestation. In addition, the Haitian Government would use its power of eminent domain to secure the use of privately held, nonproductive land in these categories. The terms in both cases would include a lease rate of about 6 percent per year of the lands' current use value paid by FORTEC to the owner of record. The franchise would prohibit the production of wood from any lands in Haiti unless for the personal use of the lands' owner. The franchise would require FORTEC to franchise/license all bona fide charcoal producers to cut, or buy already-cut, wood under the direction of FORTEC and to produce charcoal in an energy-efficient manner. FORTEC would also be required to provide and encourage the use of advanced technology for upgrading the charcoal production process. The marketable charcoal output per unit of wood consumed by the process in common

use in Haiti can be increased by 50 to 100 percent with the use of readily adaptable technology.) The franchise would also provide a means for crediting FORTEC with some portion of the agricultural and hydroelectric production benefits derived from the reforestation and forest management functions. The franchise would also be the vehicle for establishing certain standards, goals and responsibilities. A specific entity in the Haitian Government (probably the Department of Agriculture) would be the responsible franchising agent.

Conclusion

The proposed altered forest-use system would add one new element to the present four-element system. New relationships would be established to make the proposed system self-sustaining and responsive to the energy needs of the people of Haiti and to the need to renew the resource upon which the energy supply is based.

Many questions remain to be answered concerning the details of the new element (FORTEC). The relationships between the various elements must be detailed, operations must be costed, and an analysis must be made of the overall effect this altered system will have on charcoal production, charcoal price to the consumer, employment, and other beneficiaries.

This proposed system will use the public and private

sectors, with minimal disturbance of the present arrangements, to reverse the environmental and ecological deterioration attributable to deforestation in Haiti. It will also tend to insulate the poor in Haiti - who depend on charcoal as their energy source - from the international vagaries of petroleum supplies and costs. The proposed system can also be expected to improve employment opportunities in the near term as well as in the future.

R.D. MOELLER

September 29, 1978

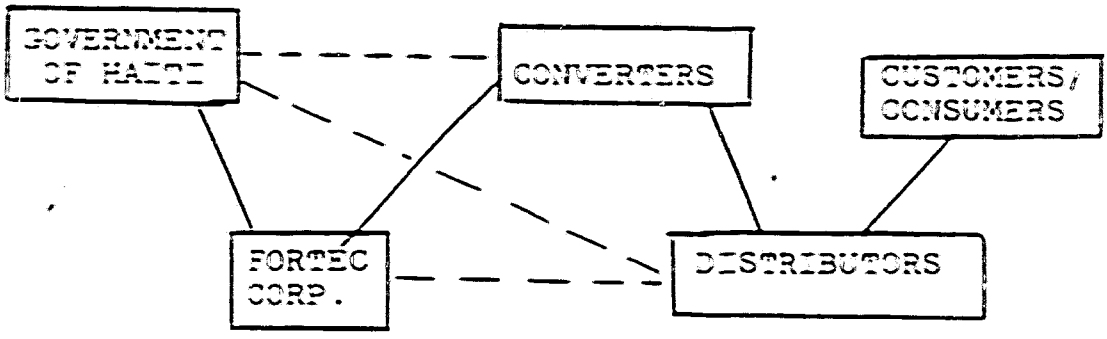
FOREST TECHNOLOGY CORPORATION ----------FORTEC Corp. Definition

Ownership structure
Income sources/customers
Expenses/suppliers
Employees/skills/terms

- R & D
- Reforestation
- Forest Management
- Wood Production
- Wood Conversion ----------Business Analysis of Each Conversion Product
  - Charcoal
  - Pulp
  - Construction Material
    - Lumber
    - Particle board
    - Plywood

Market Analysis
Distribution System
Technology/process choices
Labor requirements
Capital requirements
Other resource req.

SYSTEM
ELEMENT RELATIONSHIPS



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APPENDIX A

DOC.PEPA/HAITI 78/008
CLOTURE

Port-au-Prince
Haiti

février-juin, 1978

ORGANISATION DE LA PRODUCTION DU CHARBON DE BOIS DANS LA REGION DU NORD'OUEST

SYNTHESE DU PROJET

1. Les Antécédents

Le bois a toujours été exploité en Haiti de façon anarchique, particulièrement pour la production du charbon de bois, principal combustible utilisé par la population urbaine haitienne pour ses besoins en énergie domestique. A côté de véritables désastres écologiques que cette anarchie engendre, les principaux centres urbains du pays confrontent actuellement un problème sérieux d'approvisionnement en charbon de bois. Il y a lieu d'intervenir pour éviter une crise beaucoup plus aigue.

2. Nature du Projet

Le Projet se rapporte à l'organisation de la production du charbon de bois dans le Nord'Ouest. Il est étudié pour une période de vie utile de 25 ans. L'établissement du Projet comportera des activités de reboisement, l'encadrement des charbonniers en vue d'une utilisation rationnelle du bois, sur la base de matière première renouvelable, et l'organisation de la commercialisation du charbon de bois.

3. Objectifs

L'objectif principal du Projet est l'organisation de la production du charbon de bois, par la rationalisation de toutes les activités (reboisement, organisation des charbonniers, transport et commercialisation de la production), qui s'y rapportent, en vue de contribuer à la satisfaction de la demande de ce produit, de lutter contre l'érosion et d'améliorer les conditions de vie des charbonniers.

Dans cette optique, 5.800 has seront reboisés, dont 5.600 suivant la méthode classique (plantations rationnelles) et 200 suivant la technique

de la mise en défens. Pendant ce temps (9 ans) des méthodes de coupe plus rationnelles seront enseignées aux paysans, ils seront également conseillés sur un mode de commercialisation plus rémunérateur, qui sera, à la dixième année, la principale activité du Projet.

4. Localisation

Le Projet sera implanté dans le Département du Nord'Ouest. Il s'étendra sur tout l'arrondissement du Môle St-Nicolas : 123.000 hectares dont la végétation caractéristique est une zone de forêt sèche peuplée de plantes aérophiles.

5. Agence d'Exécution

Pour l'exécution du Projet, il sera créé une agence spéciale (Agence d'Organisation de la Production du Charbon de Bois dans le Nord'Ouest A.O.P.C.B.N.O.) qui relèvera directement de la Direction Générale du DARNDR. Cette agence aura son siège dans l'aire du Projet, et sera chargée de l'organisation et de la Coordination de toutes les activités se rapportant au Projet.

6. Activités

Etablissement de pépinières : Dès la première année, 4 pépinières seront établies pour desservir les différents sites de reboisement;

Topographie : Délimitation exacte des aires à reboiser par une équipe topographique au cours de la première année;

Plantations : Pendant 8 ans (2ème à 9ème année), 5.600 ha seront reboisés à raison de 700 ha/an; dans cette perspective, des opérations de désherbage et de regarnissage sont également prévues;

Mise en défens : 200 ha seront mis en défens. Il sera interdit tout passage et tout pacage sur ces terres qui seront surveillées, dès la première année, par deux garde-forestiers;

Animation : En vue de l'exploitation rationnelle du bois, des comités de charbonniers seront formés par des animateurs polyvalents du Projet;

Production de Charbon : Le Projet adoptera la technique traditionnelle de production : carbonisation dans des meules ou charbonnières. Cette technique donne de très bons rendements et permet l'utilisation de beaucoup de main d'oeuvre;

Commercialisation : L'organisation de la commercialisation du charbon de bois (mise en sac, transport, vente) sera la principale activité du Projet à partir de la dixième année.

7. Coût et Financement

Le coût total du Projet s'élèvera à 14.260.521 gourdes, y compris les 10% d'imprévus. Ces dépenses seront effectuées durant les 10 premières années ou période d'implantation du Projet.

Le financement du Projet sera assuré par le Budget National de Développement (CONADEP), le Fonds Spécial de Reboisement (DARNDR), et probablement le Fonds Agricole Allemand (HACHO).

8. Avantages

L'un des premiers avantages du Projet est une augmentation sensible de la production du charbon de bois. En effet, des terres prstiquement déboisées vont pouvoir donner en 16 ans 4.260.087 sacs de 30 kg de charbon de bois. Cette production fera gagner à l'économie haitienne environ 31.704.780 gourdes en évitant au pays l'importation de l'équivalent en mazout par exemple.

La population de l'aire concernée tirera également de grands bénéfices : 868.000 journées de travail seront créées en 10 ans, le revenu connaitra

une augmentation de 247% passant de ₲ 600 à ₲ 2.080.

Ce sera enfin 5.800 hectares soustraits à l'érosion.

9. Evaluation Economique

Les calculs d'actualisation au taux de 14% et étalés sur 25 ans, ont fourni les indications suivantes :

Ratio Avantages/coûts	1.43
Taux de rentabilité économique interne	18.2 %
Valeur nette actualisée	1.632.551 gourdes.

FILE

APPENDIX B

DIBBLING "LEUCAENA LEUCOCEPHALA," IPIL-IPIL SEEDS: a low cost method of reforestating cogonal areas.[1/]

In search for a way to reduce the costs of reforestating with Leucaena some are looking to the aerial seeding of Ipil-ipil seeds. This method of seeding was first tried on Corregidor, shortly after World War II. The difference between the aerial seeding of Corregidor and that of denuded mountains elsewhere is that one must remember that due to the intense bombing of that rocky island by both the Japanese and Americans, the entire island was devoid of vegetation while denuded mountains are generally covered with noxious grasses such as Imperata cylindrica "cogon" grass, Saccharum spontaneum, "talahib". These grasses not only prevent the aerial seeded Ipil-ipil seeds from reaching the ground they (1) shade out any seedlings that might sprout; (2) provide a climate for grass fires which would kill any seedlings which might become established; and (3) contain a high population of rats, that relish both Ipil-ipil seed as well as the young succulent seedlings.

On trial plots conducted in Zambales, Mindoro, and Cotabato, Leucaena leucocephala, the new "Hawaiian Giant" Ipil-ipil, seeds were dibbled directly into the ground (the method of using a pointed stick to make a hole in the ground into which seeds are dropped and then covered by a sweep of the soil by one's foot) in the following three different field preparations (1) regular Kaingin* preparation; (2) the plowing of furrows through the cogon with a carabao and plow; and (3) by the burning of the cogon prior to the seeds being dibbled into the soil. All three methods achieved a reasonable high survival rate of the Ipil-ipil seedlings (60% and over).

Perhaps the firing of the cogonal areas is one of the cheapest methods of reforestating denuded areas, although care must be taken to control and limit the area of burning for field preparation. It's best to let the young-new cogon shoots reach a height of 8-12 inches before burning off the old growth. In this way, the new growth drains the roots of its stored energy which prevents rapid recovery and regrowth. This time to burn is at the early part of the rainy season.

To insure success in the establishment of Leucaena stands, tests should be made to identify soil types and fertilizer requirements. Then prior to planting, the Leucaena seeds should be scarified, given a coating of inoculum and pelletized with necessary fertilizer additives.

By: Michael D. Benge, USAID/Manila, Agro-forestation Advisor

There are two types of Rhizobium (nitrogen fixing bacteria) that lives in symbiotic relationship with legumes and certain other plants and trees: e.g. alkali-producing Rhizobium strains are associated with legumes adapted to acid soils; acid-producing Rhizobium strains with legumes adapted to alkaline soils. Leucaena leucocephala, "Ipil-ipil," flourishes on volcanic soils of high base status such as on limestone areas. Its Rhizobium reflects this in being a fast-growing acid-producer and is highly specific. If associated with this type of Rhizobium, a nodulation response to lime on poor soils would be expected. (1)

However, there has been developed an alkali-producing strain of Rhizobium which adapts itself to Leucaena, such as the bacteria labeled CB81*. If the seeds have been innoculated with such an alkali-producing strain, lime should be used only in small quantities and only if the soil is very acid or manganese toxic or actually deficient in calcium. (1)

The Leucaena seed should first be scarified by immersing the seed in water at 80°C for two minutes. After this treatment, the seed can be dried rapidly (in the sun). It should then be stored in air tight containers. Treated in this manner, the seed will maintain as high as 97% germination after 15 months. (2)

For acid-producing Rhizobium, Australia developed a system of lime-pelleting by wrapping the seed after innoculation, in a coating of calcium carbonate stuck on with 45% gum arabic or 5% Cellofas A (methyl ethyl cellulose) or 5% pure methyl cellulose. Using this method, the acid-sensitive bacteria are protected from the acid soil while providing immediately around the germinated seed, a supply of calcium that may be needed for nodulation. Good nodulation may be induced this way by a very small amount of lime equal to about half the weight of the seed sown. (1)

On acidic soils, it is best to innoculate Leucaena seeds with an alkali-producer strain, such as CB81. After scarification of the seed, to overcome nutrient deficiencies during its establishment phase, one should pelletize the seed at a rate of: for each 4 kg. of seed; wetting is done with a 3% aqueous solution of a non-toxic sticker (cellophas), the peatnoculum (CB81) are then applied and the seeds are coated by rolling in a mixture of 1 kg. of finely ground rock phosphate with 400 grams of molybdenum trioxide added. This amount of molybdenum is enough to last for 5-7 years (molybdenum is important in the promotion of the establishment of Rhizobium). On sulfur deficient soils calcium sulfate should be used in place of rock phosphate. On acid soils calcium carbonate can be used as a replacement. (4)

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*Developed by CISRO, the Cunningham Laboratory, St. Lucia, Queensland, Australia.

In specific problem areas of Southern New Wales requiring aerial sowing, pelleting is done in what is termed the "Three Step Process" (by F. Haly of C.S.I.R.O., Canberia) (3). In this process vastly increased numbers of bacteria (700,000-300,000 per seed) are stuck on by first allowing the seed to soak up a bacterial broth, then adding a pellet incorporating a heavy innoculation with peat culture (CB-81), and finally giving an outer coat of clay and lime and gum arabic to make a tough pellet. This process is designed to overcome by sheer weight of numbers excessive mortality of the bacteria in the period between air drop and the successful germination of the seed which may be several weeks later.

A more simplified process of fertilizing is suggested by Dr. Raymond Jones of CSIRO; whereby a starter fertilizer in pellet form (superphosphate) is placed somewhat below and to the side of the already scarified-innoculated seed when it is planted. (5)

A redesigned corn planter (USAID/FSDC) will plant (dibble) 2-3 Leucaena seeds per hole while at the same time deposit a rock phosphate or superphosphate pellet 3-4 inches from the seeds. This pellet will provide a source of fertilizer for the seeds during establishment. The distance is to keep the fertilizer from burning the young seedlings. Plantings made in heavily infested cogonal areas may need one weeding at a later time. A recommended planting spacing is one meter by one meter.

On test plots 2-1/2 months Leucaena seedlings, of the same variety, were transplanted to areas adjacent to those planted by the direct seeding method. Both planting were 1 m x 1 m. The direct seeded Leucaena was planted at the same time as when the older seedlings were transplanted. The dibbled Leucaena's growth exceeded that of the transplants. Both received the same treatments of fertilizer.

To reforestate large area, dibbling, Leucaena leucocephala, "Hawaiian Giant Ipil-ipil" seeds can markably reduce planting costs.

In cogonal areas, highly susceptible to grass fire, it is recommended that firebreaks of Leucaena be planted. An easy method of establishment is by plowing furrows on the contour of the hills and planting bands of Leucaena to serve as a firebreak. This should be done prior to larger scale planting operations. For a firebreak Leucaena should be planted in a five meter band consisting of paired rows one meter apart. The Leucaena plants should be spaced from 10 to 15 cm in row and the paired rows 20 cm apart.

Technical Assistance concerning the pelletizing of Laucaena seed can be obtained from Dr. Santiago N. Tilo of the Dept. of Soil Science, UPLB. CB81 Rhizobium can be obtained from the Soil Microbiology Laboratory, Dept. of Soil Science, UPLB (Mrs. Erlinda S. Paterno) or from the Bureau of Soils.

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4. Hutton, E.M. 1977. Division of Tropical Crops & Pastures, C.S.I.R.O. Queensland, Australia (unpublished paper).

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DISSEMINATION OF HOME COOKING STOVES
MADE OF SAND AND CLAY

APPENDIX C

GOALS AND OBJECTIVES

CEMAT, an appropriate technology organization headquartered in Guatemala City, proposes to prepare artisans to build, on a commercial basis, the Lorena stove which reduces the consumption of firewood in meal preparation by more than 50% and has several other attractive features. (See "Features of the Lorena Stove" attached.) A.T. International participation in this project could lead to progress toward several objectives, including:

-- the diffusion of an appropriate technology in such a way that its further dissemination becomes self-sustaining. A sufficient number of stoves will be constructed to insure that the use of the Lorena becomes widespread and that some of the individuals trained in stove construction continue to earn their livelihood by building stoves after the life of the project.

-- the practical demonstration of a technology of potential importance to several large and populous areas of the world where firewood, a basic source of energy, is in short supply.

-- the diffusion of a useful home stove which has been modified by local people, which is inexpensive (each stove costs from $15 to $30), and which is made almost entirely of local materials.

-- the diffusion of a technology which makes life easier, particularly for the women who do the cooking in poor households.

-- the strengthening of a significant organization which could play a vital role in promoting appropriate technology within the Middle American area, which includes Mexico, the five Central American countries and Panama.

FEATURES OF THE LORENA STOVE

These are among the advantages of the Lorena stove:

— It uses less wood, about one-third to 50% of the firewood used previously in open hearth cooking, according to individuals interviewed by A.T. International staff in rural Guatemala. This estimate of the firewood savings was confirmed by a 1977 field survey of 50 states carried out in Guatemala by ICADA (Investigaciones Asociadas del Altiplano). ICADA developed the Lorena design from Indian (Asian) models.

-- Because the smoke is vented through the roof of the dwelling by a chimney, the Lorena does not fill the kitchen with smoke.

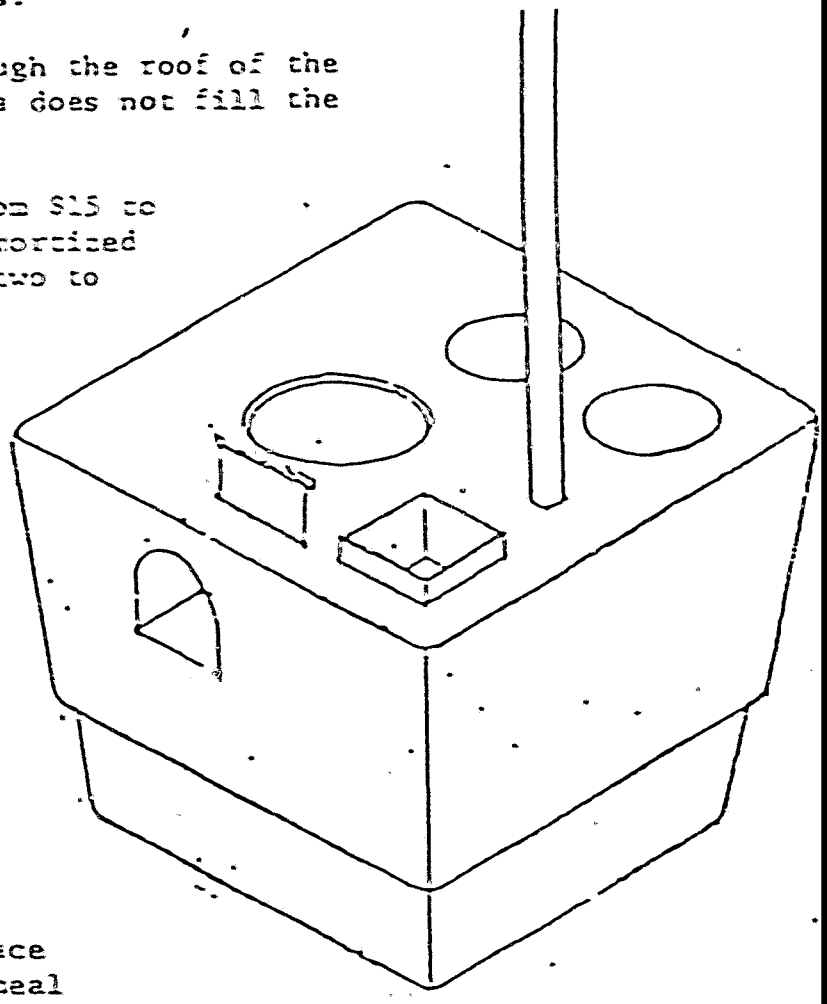
— It is cheap: the stove costs from $15 to $20 to build, and this cost is amortized by savings in firewood within a two to three month period.

-- With only a short instruction course, local artisans can build a Lorena in two to three days.

-- The stove burns almost anything: bits and pieces of cast-off wood, rolled paper or cardboard, sugar cane stalks etc.

-- Because it holds heat well, the stove helps to heat highland homes where temperatures are often chilly.

— The stove provides a raised surface on which to store foods used in meal preparation.



Drawing by CEMAT

-- The stove is so engineered that its four burners provide various intensities of heat, which jibe nicely with foods eaten by rural families.

-- The Lorena stove reduces the time needed for meal preparation by from one-half to one-third according to people interviewed by A.T. International staff.

— The stove is attractive. Users interviewed by A.T. International staff praised its "modern" look.

— The Lorena is constructed of local materials except, in some cases, where the chimney is made of galvanized iron.

BACKGROUND/RATIONALE

The use of forests to provide firewood has lead to widespread deforestation in Guatemala. This has contributed to soil erosion and drainage problems. The increasing scarcity of trees has meant that peasants either spend more time going longer distances to collect firewood or pay higher prices for this basic source of home energy. This problem has been documented in many countries; in some instances, it has resulted in desertification.

APPROACH

To begin its program CEMAT proposes to conduct twelve one-week courses in villages in Guatemala's highlands. It takes approximately one month to prepare each course, allowing time to make local contacts, select participants, gather materials, and construct demonstration stoves.

Each course will be held in the home of a campesino desirous of having a Lorena and attended by from ten to twelve individuals (men and women) who will be taught how to construct and use the stove by CEMAT technicians. One or two demonstration stoves will be built during the course. The courses will be organized by CEMAT in such a way as to encourage the beneficiaries to consider the technology involved and the possible adaptations which would make it more appropriate for their particular resources, needs, and wishes.

The courses are aimed at creating a cadre of artisans who will become multipliers — artisans sufficiently enthusiastic about the features of the Lorena that they will want to participate in the commercialization of the technology. Based on CEMAT experience, of 12 participants in each course, six will opt to build stoves in their own homes. Three participants will go on to become Lorena stove builders at least part-time. Since half the cost of a Lorena is labor, the multiplier can earn from $8 to $15 per stove.

Later on the multipliers will participate in follow-up courses conducted by CEMAT to insure that their stove-building skills reach a high standard of excellence. Upon completion of five stoves, each multiplier will receive special recognition in the form of a CEMAT diploma. An estimated 400 to 500 stoves will be constructed during the two years of the project. CEMAT maintains that this is the number required to assure that future stove construction is carried out on a self-sustaining basis without further grant-supported intervention by CEMAT.

As an ancillary activity CEMAT will be providing instruction in nutrition. Participants will learn to improve the nutritional quality of food through actual cooking exercises on the Lorena. CEMAT will provide them with information on the healthful characteristics of locally available plants, and promote discussion of various methods for preventing food contamination.

CEMAT also plans to publish information and manuals about the Lorena, and to provide this information to interested groups or individuals in other countries. CEMAT, incidentally, has already trained representatives of Save the Children Federation of Honduras in the Lorena technology, and this led to the initial dissemination of that technology there. Due to information provided by CEMAT, groups in southern Africa are developing courses in the Lorena and its construction, further disseminating the technology.

There are some risks in the project. Special care must be exercised to insure that clay which fires well is used in stove construction. In a few past instances, an improper mix of sand and clay or the use of improper drying and curing procedures have led to a cracking of the stove. However, for the most part the materials and skills needed are widely available in the Guatemala highlands.

At present CEMAT's activities include research into relevant technologies, and assistance to communities to build networks for exchanging experiences of mutual interest. It promotes information exchange and contact among groups in the appropriate technology field on a national and international basis. CEMAT also publishes do-it-yourself manuals on the construction of latrines and septic tank systems, and information on rural health (i.e. medicinal and nutritional plants, the operation of health centers etc.) and on agricultural development projects. Moreover, it is developing technologies for low cost housing and has been constructing demonstration units. There is thus some risk stemming from the possibility that CEMAT might become over-extended. This is an aspect which A.T. International staff will be monitoring closely.

ORGANIZATION AND MANAGEMENT

CEMAT is a non-profit organization founded in February 1976 after the disast Guatemalan earthquake. As of early 1978 CEMAT had a permanent staff of 19 workin on various projects under the leadership of Roberto Caceres, 34, who has played a central role in developing the Lorena project. Caceres is the founder and direct of CEMAT. Like his two younger brothers, also associated with CEMAT, Roberto has worked on rural development in other countries in Latin America and Africa. He i especially well qualified in non-formal education and technology dissemination techniques.

The CEMAT stove project will be headed by Alfredo Perez, a Guatemalan of Indian descent. Perez was specifically recruited by CEMAT because of his rura background, his ability to communicate with Indians in their own tongues, and his reliability as a field worker. During the two-year life of the stove project Perez will personally visit every area in which courses have taken place at least once every forty days, to continue to evaluate the technology and its disseminatio

RESOURCE REQUIREMENTS

The project will cost a total of $110,000 over a two-year period. It is proposed that A.T. International provide a grant of $80,000, while CEMAT will be contributing $30,000 from income generated by the project. All project funds will be spent in Guatemala. CEMAT routinely charges a small amount for participation in the training courses and also a nominal charge for its publications. It is CEMAT policy not to give things away. It is anticipated that IBM's Scientific Center in Mexico will use its remote sensing capabilities to support this project. Following discussions with A.T. International staff this resource will be made available without cost to assist CEMAT in the identification of the location and extent of suitable deposits of clay.

The tentative project budget is as follows:

— Personnel	$ 38,000
— Transportation	16,000
— Materials, supplies and equipment	16,000
— Nutrition component	8,000
— Overhead costs	16,000
— Evaluation	4,000
— TOTAL	$110,000

APPENDIX D

Project A-1823
AID/ta-C-1290

PYROLYTIC CONVERSION OF AGRICULTURAL AND FORESTRY WASTES IN GHANA

-A FEASIBILITY STUDY-

Prepared for

Agency for International Development

Office of Science and Technology

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July 1976

Pyrolysis is a process ancient as civilization itself. Charcoal production in almost every culture has been a mark of the beginnings of organized society. However, pyrolytic conversion of wood into charcoal by means of the traditional batch-type "earth mound" processes is very inefficient and does not permit recovery of another, almost equally valuable product of pyrolytic conversion -- the pyrolytic oils. These oils cannot be ignored, especially today, since they represent a potential source of energy for industrial and utility boilers. The corrosive nature and odor inherent in the oils requires special handling and storage procedures.

In addition to the charcoal and oil, another by-product of pyrolysis is a clean-burning but relatively low-energy gas which could be used in many situations where a gaseous fuel is required.

While earth mound kilns are not very efficient, several types of inexpensive, easily constructed kilns are available today that can produce large amounts of charcoal with relatively minor labor requirements. Although these kilns do not presently allow oil recovery, they do provide a low-cost means for charcoal production and are especially well suited for reforestation wastes -- the larger pieces in particular. Since the major waste production in Ghana is currently from the reforestation project sponsored by the Ghana government to promote oil palm production, the use of simple low-cost kilns, such as the Missouri kiln (1),[1/] as a major means for energy conversion should not be overlooked. The charcoal thus produced would be well suited for domestic consumption and also could be used as a fuel in coal-fired boilers such as locomotives, which presently require expensive imported coals.

1/ Earl, D.E. A report on Charcoal. Food and Agriculture Organization of the United Nations. Rome. 1974.

While the potential for charcoal production using the kilns is large, there are still problems associated with the collection of the wastes. This is especially significant so far as the reforestation project is concerned. In situations where the wastes are already collected, a promising means of pyrolytic conversion involves continuous, rather than batch (kiln)-type, processes. Since very large quantities of these process wastes suitable for continuous processing presently are available in Ghana, it appears that continuous processes operating on these type wastes offer an attractive alternative to kilns, especially since oil recovery is then feasible.

Various types of modern continuous-flow pyrolysis processes have been veloped recently in the United States and elsewhere to emphasize the production of one or more of the products of pyrolysis. Characteristically, these processes require the wastes to be shredded into relatively small pieces which can be handled easily. Primarily, these processes tend to maximize the production of gas, with the oil a secondary by-product and the char reduced essentially to ash. This is because most of these processes have been developed to deal with municipal wastes and have assumed the proximity of a large, gaseous-fueled industrial or utility type boiler. Clearly emphasis on gas production for a system to convert agricultural and forestry wastes would be a serious mistake because of the problem of storing and/or transporting the gas to a user. There is a system, i.e., the Garrett process, that emphasizes the production of oil, but it is very complex and requires significant preprocessing of the wastes. Its feasibility when applied to agricultural and forestry wastes and when operated in a rural environment is doubtful.

Typically, high-temperature processes emphasize gas production, while low-temperature processes emphasize char and oil production. Conveniently, low-temperature processes can be made of cheaper materials and can be made to operate in a simpler manner than the higher-temperature processes. This favors their use in a rural environment, especially in a developing nation such as Ghana, where spare parts are not always conveniently available.

A number of continuous low-temperature pyrolysis processes also have been developed throughout the world in recent history; perhaps the simplest and most promising involve vertical retorts through which the feed passes. In almost every case these processes are self-sustaining, with the heat required to dry and carbonize the as-received wet wastes being supplied through combustion of

either a small part of the feed itself or the products of the pyrolytic conversion. All these processes possess basic similarities and differ mainly in the manner in which the auxiliary heat to facilitate the drying and pyrolytic conversion is applied.

Several examples of this type of retort include: the basic Stafford retort (2) used very widely over the past 50 years in the U. S. and elsewhere for production of charcoal and liquid by-products; the Mellman retort (3); the Lambiotte retort (4); the de Bartolomeis design (5); the Barneby process (6); the Georgia Tech design (7).

While continuous processes allow oil recovery, they generally are more complex and more expensive than simple kilns. Likewise, they are more vulnerable to shutdowns in LDC's because of reduced spare part availability. Moreover, they require some or extensive preprocessing of the waste feed.

Since the character of the wastes in Ghana varies widely, a process that would accept all kinds of materials in various sizes and shapes and yet still allow oil recovery would be most desirable. Clearly it also should maximize labor utilization, be of a rugged, simple design, and be as inexpensive to manufacture within Ghana as possible. A preliminary description of a system having these properties is presented in a later section.

In reviewing the previously mentioned problems of using agricultural and forestry wastes for energy production, it is useful to note that low-temperature pyrolysis systems produce dense, dry, high-energy fuels that can be easily stored and transported and used in existing facilities with little or no modifications. By making the system portable, the seasonal character of the wastes can be dealt with. Thus the problems characteristic of using these wastes can be significantly reduced or resolved using low-temperature pyrolytic conversion.

APPENDIX E

AGRO-FORESTATION

As defined - the planting of denuded or cultivated slope lands with perennial tree-species and simultaneously cultivated with other tree species and/or with annual crops. The perennial trees may be in a pure stand but cultivated on a short rotation basis for the specific purpose of producing particular end-use products for specific markets. Agro-forestation may be multi-purpose in nature whereby Leucaena could be first planted and harvested for wood use such as banana props, fuel-wood, etc.; then allowed to regenerate to be harvested as forage, green fertilizer, seeds, etc.

Properties - Leucaena, as a member of the legume family, is known to possess the characteristics of nitrogen fixation in its roots as well as the accumulation of nitrogen, phosphate and potash in its leaves. The exact quantity of the available amounts of each mineral is yet to be determined but tests carried out at the University of Hawaii (Guerrero 1976) has established the fact that it produces sufficient quantities of N-P-K to adequately fertilize (applied as a green manure mulch) annual crops at a ratio of 1 ha. of Leucaena to 2 has. of annuals. This is, of course, dependent upon soil fertility and population density. Leucaena's reputation as a fast growing species (Brewbaker 1975, Bawagan and Semana 1976) makes it a financially competitive species to be seriously considered as both a forest crop on a short rotation as well as a viable pioneer reforestation species for denuded lands (Francia, 1961 and Amos, 1955).

Cultural Practices - Leucaena used as a component in an Agro-forestation scheme can serve well as a companion tree crop and shade tree. Planted as a source of fertilizer it can easily be worked into schemes incorporating banana, abaca, coconut, coffee, cacao, bamboo or other trees. Leucaena which is planted for the primary purpose of short or long term wood production such as firewood, charcoaling materials, etc. could be feasibly interplanted with shade tolerant annual crops such as the family of Dioscorea and the edible aroids. Other schemes could be devised whereby denuded hillsides in proximity to lands cultivated by shifting (swidden slash and burn) cultivators could be planted to Leucaena in five meter bands on the contour of the hillside with interspacings of one meter by one meter; and alternating ten meter bands could be left open to be planted with annual crops of corn, rice, etc. Leucaena after 1-1/2 to 2 years could be harvested as a wood crop and the remaining stumps allowed to coppice. The regrowth could be cut and applied as a green manure to annual crops planted in the vacant areas. Such a planting would allow for a well established root system to develop which would insure larger supplies of minerals stored in the Leucaena

leaves, giving them a greater fertilizer value. Agro-forestation schemes such as these would stop the destruction of valuable timber cut in the slash and burn practices; reduce soil erosion and degradation, while decreasing the area of land required to support shifting cultivations, transforming them into a sedentary (stationary) agriculture practice.

Leucaena - is adaptable to varying systems of cultivation aside from the above mentioned and numerous schemes may be in actual practice, but, as of this time they are unknown to those researchers. Much research is needed to answer the many questions which may evolve from the use of Leucaena in Agro-forestation systems; this is in the areas of production and environment. Yet such agro-forestation schemes offer promising alternatives to the existing problems faced, embracing hillside farming and denudation.

Production estimates - Agro-forestation systems which include Leucaena have the potential to increase income of the hillside and shifting swidden (slash and burn) cultivators. In the case of the shifting cultivators it should decrease his labor input of field preparation which could be diverted to other activities to include increased area which he could cultivate. In areas of limited available arable land, it is important to note that an increase of one-third total land area would be required in a system utilizing Leucaena as a source of cut and carry fertilizer. Such a system would provide a source of free fertilizer, a commodity which is normally unavailable to the shifting cultivators. Brewbaker and (Guerrero 1975) reports a 133% yield increase of corn fertilized with Leucaena over that of an unfertilized plot. Francia (1961) reported a doubled income return per hectare by growing a common Philippine variety of Leucaena as a firewood compared to rice, corn, coffee and bananas.

Bawagan and Semana (1976) recorded a trunk yield of 45 cu.m./ha.yr. and a branch yield (down to four cms.) 10 cu.m./ha./yr. on a stand of K-28 Leucaena planted at Canlubang Sugar Estates, Calamba, Philippines. Other projected yields from dense stand of Leucaena at the University of the Philippines at Los Banos were considerably higher. A yield of this type sold at ₱32.00/cu.m. would give a farmer an income of ₱2,240/ha./yr. (calculated @ ₱7.5 to $1.00 U.S.). Benge and Curran (1976) estimated that Leucaena firewood farmers at Los Banos were capable of earning ₱5,622.21/ha./yr. by selling wood at a roadside price of ₱1.20 per bundle. Lugod (1975) estimated yields of 30 mt./ha. of a variety of the root crop Dioscorea could be gained from interplanting this crop under a normal forest canopy. This yield seems exceptionally high. A market price of Dioscorea at ₱.50/kg., multiplied by Lugod's projection of 30 mt./ha., would give an income of ₱15,000/ha./yr. in

addition to the wood crop. Root crops normally give a 25% to 50% response to fertilizer applications. Root crops planted under Leucaena would presumably give a higher yield.

PICOP (Paper Industries Corporation of the Philippines) (1975) gave a profit of ₱2,312.00/ha/yr/ for tree farmers who raised Albizia falcataria. This was over and above their maintenance crops of rice, corn, sweet potatoes, etc. which had been intercropped. Leucaena sold as a firewood or converted to charcoal has a much higher per cu. meter value than that of Albizia. Benge and Curran (1976) gave a per ha. income of ₱2,400 for charcoal producers who sold their product at a wholesale price of ₱200.00 ($26.50 U.S.)/M.T. The aforementioned Agro-forestation production estimates are by no means conclusive. Yields, of course, depend upon soil fertility, management practices as well as many other factors . The net profit gain depends upon the type of product, market price and logistics involved. The point that is stressed is that Leucaena is a versatile plant which can be utilized in many ways in systems which will reforest (not in the classical sense); offer environmental protection to the soil; while producing food and/or forest products with a market value to enable hillside farmers to significantly improve their standard of living.

FIRE PROTECTION AND WINDBREAK

Fire has always been a major problem in reforestation. Each year, sizable areas of forest lands are burned to waste. Firelines constructed by clearing 10-20 meters wide strips around the plantation are not only expensive but also not effective and short lived. Leucaena leucocephala planted very closely on newly constructed firelines could provide an effective, inexpensive and year-round fire break. It will also serve as an efficient windbreak.

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